WIC Participation and Pregnancy Outcomes: Massachusetts Statewide Evaluation Project

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Abstract: The effects of WIC prenatal participation were examined using data from the Massachusetts Birth and Death Registry. The birth outcomes of 4,126 pregnant women who participated in the WIC program and gave birth in 1978 were compared to those of 4,126 women individually matched on maternal age, race, parity, education, and marital status who did not participate in WIC. WIC prenatal participants are at greater demographic risk for poor pregnancy outcomes compare to all women in the same community. WIC participation is associated with improved pregnancy outcomes, including, a decrease in low birthweight (LBW) incidence (6.9 per cent vs 8.7 per cent) and neonatal mortality (12 vs 35 deaths), an increase in gestational age (40.0 vs 39.7 weeks), and a reduction in inadequate prenatal care (3.8 per cent vs 7.0 per cent). Stratification by demographic subpopulations indicates that subpopulations at higher risk (teenage, unmarried, and Hispanic origin women) have more enhanced pregnancy outcomes associated with WIC participation. Stratification by duration of participation indicates that increased participation is associated with enhanced pregnancy outcomes. While these findings suggest that birth outcome differences are a function of WIC participation, other factors which might distinguish between the two groups could also serve as the basis for alternative explanations. (*Am J Public Health* 1984; 74:1086–1092.)

Introduction

Efforts to improve the health status of pregnant women and their young children through nutritional supplementation and education have long been a part of public health programs in the United States. The Special Supplemental Food Program for Women, Infants and Children (WIC), established in 1972, is the largest and most specifically targeted public health nutrition program in the United States today. The WIC program is designed to reach high-risk pregnant and lactating women, infants, and children up to 5 years of age with supplemental foods and nutrition education, as an adjunct to good health care.[1]

WIC is the first federal nutrition program to use identifiable nutritional risk, in addition to low income, as a criterion for eligibility. Since its inception, WIC has grown to provide benefits to 2.9 million persons monthly, at a cost of $1.36 billion in fiscal year 1983. An estimated 500,000 pregnant women now participate in the WIC program.

Eligible participants receive a monthly set of food vouchers redeemable at local grocers for specific foods tailored to individual needs. Allowable foods include: milk, cheese, iron-fortified cereal, 100% fruit juices, eggs, dried beans, peanut butter, and iron-fortified formula for infants. The cost of the food package is approximately $30 per month, provided at no cost to the participants. Nutrition education is also provided. A more complete description of the WIC program appears elsewhere.[2]

The WIC program, despite its magnitude and its clearly stated public health goals, has not been extensively examined. The lack of research may be the result of a moral acceptance of the virtues of feeding high-risk women or of the methodological difficulties of conducting quality research in a large, decentralized nutrition program. The latter include the difficulty of obtaining a proper comparison sample, the lack of data collected uniformly across program sites, and the need for large sample sizes to show stable program effects. To date, only two evaluations of prenatal participation in WIC based on perinatal outcomes have been published. Despite quite divergent methodologies, Edozien, *et al*,[3] and Kennedy, *et al*,[4] both reported that WIC participation is positively associated with maternal weight gain, infant birthweight, and gestational age, and that the WIC programs' effectiveness is enhanced by increasing duration of participation. Others maintain that the value of WIC is unproven.[5]

This paper reports the results of the Massachusetts WIC Statewide Evaluation Project, which examined the association between maternal participation in the WIC Program in 1978 and the outcomes of pregnancy. Specifically, four questions were addressed:

- Does the WIC Program reach its target population?
- Is WIC participation associated with more positive outcomes of pregnancy?
- Are the effects of WIC participation similar across all high-risk subpopulations?
- Are the effects of the WIC program enhanced with increased duration of participation?

The Massachusetts WIC Program

The Massachusetts WIC program is similar to WIC programs nationally. In 1978, it operated through 23 nonprofit local health centers and social service agencies under contract with the State Department of Public Health. Approximately 22,000 persons participated monthly, of whom over 4,000 were pregnant women. At the time of the study, geographic eligibility, in addition to income guidelines and nutritional risk, was a criterion for WIC participation.

In Massachusetts, the issuance and redemption of all WIC food vouchers is centrally monitored through a single computerized bank control system. This system allows for an accurate documentation of the names, duration of participation, and number of vouchers redeemed for all prenatal WIC participants.

Methodology

Study Population

The basic design of the study is a direct comparison of the pregnancy outcomes of two groups of Massachusetts women who gave birth in 1978: those who participated in the WIC prenatal program, and a matched control group of non-WIC women. The derivation of the study population and

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TABLE 1—Selected Maternal Demographic Characteristics, 1978: WIC Participants, Catchment Area Residents and All Massachusetts Residents

Characteristics	% WIC Participants	% Catchment Area Residents	% All Massachusetts Residents	% WIC Saturation of Catchment Area
Age				
≤17 years	12.2	6.0	3.8	36.4
≤19 years	28.6	16.9	11.5	30.4
Education				
≤9 years	14.9	10.5	5.1	25.4
<12 years	49.2	31.5	19.0	28.0
Marital Status				
Unmarried	40.7	23.9	13.7	30.6
Married	59.3	76.1	86.3	14.0
Race				
Black	23.8	16.0	6.2	27.0
White	73.6	81.6	91.8	16.2
Parity				
1	44.9	45.9	44.6	17.6
5+	6.5	4.1	3.3	28.4
TOTAL (N)	(4,126)	(22,995)	(67,187)	

study data results from the linkage of two computerized data systems: the WIC bank voucher system, and the State Birth and Death Registry. Appendix A summarizes the three steps were involved.*

First, the names of all women who registered as a WIC prenatal participant were drawn from the WIC computerized participant voucher reports (N = 4,898). Data on the duration and number of vouchers cashed per month were also extracted. Failure to pick up vouchers for two consecutive months resulted in administrative termination from the program. Administrative termination codes were noted on 525 names. Specific causes for termination were known for 172 of the names, while 353 names remained unaccounted for. As this was a study of women who actively participated in WIC, all 525 women with termination codes were excluded from the study, leaving 4,373 eligible participants.

Second, each mother's name (plus town of residence, race, and expected date of delivery) obtained from the WIC reports was linked, by hand, to the corresponding infant's birth certificate record listed in the state's computerized Birth Registry file. Twin births (46) and know fetal deaths (15) were excluded, as were 191 names which could not be positively linked.

Third, each WIC participant was individually matched to a control subject on the basis of five maternal characteristics available on the birth certificates: age, race, parity, educational level, and marital status (Appendix B). Controls were selected from the pool of 64,000 remaining non-WIC births in the computerized State Birth Registry (68,000 total 1978 resident births minus the approximately 4,000 WIC births). Matching was performed by hand with the aid of computer-derived lists. Efforts were made to facilitate geographic similarity of the WIC and control populations; matching was attempted first within the same catchment area, then within similar types of towns, and finally anywhere within the state. The first eligible woman meeting all five study criteria was chosen. All matching was exact.** Five subjects who could not be matched were excluded.

The final sample, composed of 4,126 matched pairs of WIC and non-WIC mothers, included 95 per cent of all eligible 1978 prenatal WIC participants in Massachusetts.

Derivation of Study Data

Once the WIC cases and matched controls were selected, all data from their birth certificates were extracted for analysis. The Massachusetts birth certificate provides data on maternal demographic characteristics, prenatal care, and pregnancy outcomes.[6] The State Death Registry file provides information on all neonatal deaths between birth and 28 days.

Data Analysis

The demographic characteristics of WIC participants were contrasted with the characteristics of all pregnant women residing in the same catchment area and statewide in 1978. WIC participants were then compared directly to their matched non-WIC controls on the birth outcome measures. Differences were statistically examined by use of paired T-test comparisons for continuous data items and by McNemar Chi-square comparisons for ordinal data items. Pairwise deletions were used for any subject pair having missing data. The women in the WIC sample and their matched controls were then stratified into a number of subpopulations for separate analyses of birth outcome differences. These subgroups were defined on the basis of demographic characteristics or duration of WIC participation and are not statistically independent of each other.

Results

WIC Population Characteristics—The comparison of selected demographic characteristics (Table 1) suggests that the WIC population comes from demographic groups at higher risk for poor pregnancy outcomes. The WIC prenatal population is younger and less educated, contains more unmarried and minority women, and has a larger number of high parity births compared to all women who reside in the same WIC catchment area or statewide and gave birth in 1978. The Massachusetts WIC program sites in 1978 were located in more disadvantaged areas of the state and, within the program, the higher risk subpopulations were proportionally more heavily represented. Almost 18 per cent of all women who gave birth in 1978 in WIC catchment areas were WIC prenatal participants.

Overall WIC and Control Group Comparison—The

* Detailed procedure manual available from authors upon request.

** Since the computerized birth registry is sequenced by date of birth, the control subjects tend to be born earlier in the year. Given the expansion of the WIC program in Massachusetts during 1978, the WIC subjects tend to be born later in the year. No seasonality bias in birth outcomes was noticed.

TABLE 2—Comparison of WIC and Control Birth Outcomes

Findings	N	WIC	Control	Difference	95% Confidence Interval
Birthweight					
Birthweight (in grams)	4121	3281	3260	+21°	±23.4
Per Cent Low Birthweight	4121	6.9	8.7	−1.8**	±1.1
Per Cent Small for Gestational Age†	3615	5.0	5.0	0.0	±1.0
Gestation Adjusted Birthweight (in grams)††	4121	−52.0	−48.4	−3.6	±21.9
Gestation					
Gestational Age (in weeks)	3722	40.0	39.7	+0.3***	±.1
Per Cent Premature (<37 weeks)	3722	8.5	9.8	−1.3°	±1.3
Morbidity					
Per Cent with Complications of Pregnancy, Delivery and Labor	4115	20.2	21.1	−0.9	±1.7
Per Cent with Congenital Malformations	4126	1.7	1.7	0.0	±0.6
Per Cent Low (≤5) Apgar Score (one minute)	3732	5.1	5.7	−0.6	±1.0
Per Cent Low (≤5) Apgar Score (five minute)	3716	.5	1.0	−0.5*	±0.4
Mortality					
Number of Neonatal Deaths	4126	12	35	−23**	±13
Prenatal Care					
Number of Prenatal Visits	3721	11.2	10.8	+0.4***	±0.2
Month Prenatal Care Began	3721	2.7	2.9	−0.2***	±0.1
Adequacy of Prenatal Care Index†††	3675	1.34	1.41	−0.07***	±0.03
Per Cent with Inadequate Care	—	3.9	7.0	−3.1***	±1.0
Per Cent with Intermediate Care	—	26.7	26.7	0.0	±2.0
Per Cent with Adequate Care	—	69.4	66.3	+3.1**	±2.1

° = $p < .10$.
* = $p < .05$.
** = $p < .01$.
*** = $p < .001$.

†Small for gestational ages is defined as an infant weighing below the 10th percentile for their gestational age at birth. Figures derived from Battaglia and Lubchecno.[7]

††The gestational correction for birthweight is determined by subtracting the observed birthweight from the mean Massachusetts birthweight for that gestational age.

†††The Institute of Medicine adequacy of prenatal care index is a 3-point index combining the number of prenatal visits and month prenatal care began, with an adjustment for gestational age. Adequate care assumes that the first prenatal care visit occurs in 1st trimester, with one additional visit per month of pregnancy.[8]

overall results are presented in Table 2. WIC participation is associated with improved pregnancy outcomes: small improvements in overall mean birth characteristics (gestational age and birthweight) and larger reductions for some of the low frequency and marginal pregnancy outcomes (low birthweight, low 5 minute Apgar scores, neonatal mortality, and prematurity). There is a 21 per cent decrease in the incidence of low birthweight (283 WIC vs 360 control infants). The reduction in prematurity associated with WIC participation reaches statistical significance if prematurity is defined below 36 weeks gestational age (5.7 per cent vs 7.0 per cent). The mean 1 minute and 5 minute Apgar scores were not significantly different.

WIC participation is also associated with better prenatal care; there is a 44 per cent decrease in the number of women receiving inadequate care.

High Risk Subpopulations—Teenage mothers, as a group, show increased birthweight, increased gestational age, decreased LBW status, and improved prenatal care (Table 3). In general, there is an inverse relationship between age of mother and the impact of WIC on birth outcome. The youngest mothers, age 15 and under, had the largest pregnancy benefits and biggest decline in inadequate prenatal care (6.1 per cent WIC vs 18.7 per cent non-WIC).

WIC participation is associated with positive birth outcomes for Black, White, and Hispanic origin women.*** Improved birth outcomes appear strongest for women of Hispanic origin, with significant improvements in birthweight, gestational age, and LBW status, but with no changes in prenatal care. In general, the positive association of WIC participation and birth outcomes seems stronger for Blacks than for the White population, and even stronger when the Hispanic population is removed. Significant benefits are associated with WIC participation for unmarried women: improvements in birthweight, gestational age, LBW status, and adequacy of prenatal care. The trends appear similar to those for teenage women, many of whom also fall into this category. An inverse relation between maternal education and improved birth outcomes is evident. Women with less than a high school education show significant improvements in birthweight, LBW status, and adequacy of prenatal care. Stratification of the sample by birth parity revealed no consistent pattern.

Increased Duration of WIC Participation—Duration of prenatal participation in WIC is based on the number of months between the month of the first redemption of a voucher and the month of delivery. The mean duration of prenatal participation in WIC in 1978 was 4.6 months.

The cumulative impact of WIC participation on birth outcomes was examined in two ways. First, WIC participants and their matched controls were stratified into three groups based on absolute number of months in the WIC program: 33 per cent participated for one to three months; 45 per cent for four to six months; and 22 per cent for seven to nine months. Second, to compensate partially for differing lengths of gestation, participants were also stratified into four groups based on percentage of pregnancy in the WIC

*** For this analysis, Hispanic status is defined solely on the basis of maternal birth site and includes women born in Latin America, Puerto Rico, or other Caribbean Islands. Hispanics born in the US are not included. Matched controls for Hispanic origin women are not necessarily of Hispanic origin.

TABLE 3—Selected Birth Outcome Differences by Demographic Subpopulations (WIC Minus Control)

Subpopulation	N	Birthweight Difference	LBW Difference	Gestation Difference	Inadequate Care Difference
Maternal Age (years)					
≤15	95	98	−3.2	.5	−11.6
≤17	504	57	−3.2°	.5*	−7.3***
≤19	1178	38°	−3.0*	.4***	−5.2***
20–34	2781	16	−3.2°	.1	−2.3***
34+	162	−10	−4.9	.2	−0.6
Race/Ethnicity					
Hispanic origin	906	65*	−2.4*	.3*	0.8
Black	978	37	−2.1	.3**	−4.6***
White	3010	14	−1.7**	.2***	−2.6***
White—Hispanic	2298	8	−1.3	.2**	−2.7***
Marital Status					
Unmarried	1677	35°	−2.5**	.3***	−6.7***
Married	2445	14	−1.2	.1	−0.5
Education (years)					
<12	2033	36*	−2.5	.2	−4.4***
12	1498	2	−1.4	.3**	−4.0***
>12	468	10	−1.0	.1	−1.3
Parity					
1	1852	14	−1.6°	.3**	−4.0***
2–3	1956	12	−1.6	.2	−1.5*
4+	520	20	−3.3°	.1	−4.8*

° = p < .10.
* = p < .05.
** = p < .01.
*** = p < .001.

program: 32 per cent participated for 0–40 per cent of their pregnancy; 40 per cent participated for 41–70 per cent; 20 per cent participated for 71–100 per cent; and 8 per cent had unknown gestations.

The results for duration in the WIC prenatal program by number of months are presented in Table 4. Increased duration in WIC is associated with enhanced pregnancy outcomes. In particular, increased duration is significantly associated with increases in mean birthweight and gestational age, and decreases in the incidence of low birthweight, prematurity, small for gestational age (SGA), and neonatal deaths. The findings are strongest for the 7–9 month participants. It would appear that the reduction in the incidence of some of the poorer marginal pregnancy outcomes (LBW and neonatal mortality) is significant from 4–6 months of participation, while enhancement of mean birth characteristics

TABLE 4—Selected Birth Outcome Measures by Duration WIC Participation

	Months WIC Participation			Per Cent of Pregnancy WIC Participation			
Birth Outcome	1–3	4–6	7–9	Unknown	0–40%	41–70%	71–100%
Birthweight (grams)							
WIC	3236	3264	3385***	3272	3260	3269	3341°
Control	3260	3253	3274	3245	3254	3252	3291
Low Brithweight %							
WIC	8.2	7.6*	3.4***	7.7	8.0	7.6*	5.9°
Control	7.8	9.5	8.6	10.8	8.7	10.5	8.6
Gestational Age (weeks)							
WIC	39.8	39.8	40.4***	39.8	40.1**	39.9**	39.8
Control	39.8	39.8	39.7	39.9	39.8	39.7	39.8
Premature (<37 weeks)							
WIC	10.7	9.1	4.3***	12.9	10.5	8.5	9.5
Control	9.5	9.4	9.5	9.7	11.5	11.2	9.7
Small for Gestational Age %							
WIC	5.3	5.2	2.6*	8.2	6.2	6.4	4.8
Control	4.5	5.4	4.7	6.5	5.2	5.9	5.2
Neonatal Mortality (#)							
WIC	7	5*	0*	1	4	5	2
Control	12	15	8	4	13	11	7
Inadequate Prenatal Care %							
WIC	7.7	2.6***	0.6***	8.8	7.4	2.7***	0.6***
Control	6.8	7.7	5.6	8.6	6.8	8.7	5.8
Total (N)	(1365)	(1848)	(909)	(308)	(1307)	(1664)	(844)

° = p < .10.
* = p < .05.
** = p < .01.
*** = p < .001.

(birthweight and gestational age) are significant only for the 7–9 month participants.

Improved prenatal care is also associated with increased duration in WIC. Significant improvements are noted for the 4–6 month participants, and even more strongly for 7–9 month participants. However, the 1–3 month WIC participants have received less adequate prenatal care than their matched controls.

The results for percentage of pregnancy in the WIC program are also presented in Table 4. Mean birthweights and mean birthweight differences increase in a positive direction with increasing percentage of pregnancy in WIC. Both the moderate and highest percentage duration groups show decreases in LBW. The relative incidence of LBW (the WIC/control ratio) decreases with increasing percentage of pregnancy on WIC (91 per cent, 72 per cent, 68 per cent).

Gestationally based measures do not follow the prior pattern. Since the stratifying factor—percentage of pregnancy in WIC—controls in part for differing length gestations, no duration trends would be expected for gestationally based measures; none are seen for percentage premature or SGA. However, for short and moderate length percentage of pregnancies, WIC participants have significantly longer mean gestations than their matched controls. This may be an artifact, however; this stratification will bias WIC women with the longest gestations into the lower percentile categories.

Prenatal care measures are the least influenced by the two methods of analysis for duration effects. Improved prenatal care is associated with increased percentage of pregnancy in WIC. The incidence of inadequate prenatal care declines rapidly with increasing duration.

Discussion

The present study design overcomes, in part, the difficulty of establishing an adequate comparison sample for WIC evaluations by using well defined individually matched controls available from the State Birth Registry. Standardized birth outcome information collected uniformly on all births, independent of WIC participation status, should eliminate any ascertainment bias between WIC and non-WIC subjects. The inclusion of virtually the entire 1978 Massachusetts prenatal WIC population should make the results more robust than studies based on smaller samples and more limited numbers of WIC sites. The larger sample size and the matched pair study design allows for analyses of subpopulations and low frequency birth events, neither of which were accessible to earlier studies.

Presumably, if WIC is properly targeted, demographic groups that are expected to have a higher percentage of poorly nourished women[9] will be more heavily represented in the WIC population. Massachusetts WIC program sites are located in more disadvantaged areas of the state and, within the WIC program itself, the higher risk subgroups are more heavily represented. Although appropriately targeted, there are many more women eligible for the WIC prenatal program who did not or could not participate; in 1980, the federal government estimated that only 21 per cent of eligible women in Massachusetts were enrolled in WIC.[10]

Our results indicate that participation in WIC is associated with enhanced pregnancy outcomes. The direction and the magnitude of the results are in general accord with earlier WIC evaluation studies.[3,4] The small birthweight gain (21 grams) and gestational age gain (two days) suggest that overall mean birth characteristics may not be easily shifted by public health nutrition supplementation and educational programs in industrialized countries. Even the gains associated with the lengthier WIC participation (+111 grams birthweight and +5 days gestational age) are relatively small, representing no more than 2–3 per cent of the total pregnancy weight gain and gestation.

The larger reductions in the incidence of low birthweight, prematurity, and neonatal mortality suggest that nutrition intervention programs may be more effective in impacting on the poorer outcomes of pregnancy. Those at the lowest end of the birth outcome distribution seem to have benefited most from the WIC participation. It is these high risk births that public health programs such as WIC are trying to reduce; these are the births associated with later childhood morbidity, developmental delays, and higher usage of health and special education services.[11] The magnitude of the decrease in LBW infants (21 per cent) seen in this study is consistent with the prior WIC studies by Edozien, *et al*,[3] and Kennedy, *et al*,[4] which noted 23 per cent and 32 per cent LBW reductions, respectively.

The observed decrease in neonatal mortality has not been noted in earlier WIC evaluations. Approximately 50 per cent of the improvement in neonatal mortality (12.08 deaths) appears to be due to the better WIC birthweight distribution compared to the control population. The remaining improvements must therefore reflect enhanced birthweight specific mortality, although any WIC-associated causes for this cannot be determined by the present study. While prenatal care differed between the two study groups, approximately equal numbers of WIC and control births and neonatal deaths were born in level III hospitals with neonatal intensive care units and in small hospitals with under 1,000 deliveries annually. Causes of death revealed no distinctive patterns.

One must consider the possibility of neonatal deaths being undercounted. Information on neonatal deaths is derived from a different data source than all other birth outcomes measures in the study—the annual neonatal matched birth and death file from the State Death Registry. When all WIC, control excluded, and unlinked names were carefully re-examined with names in this file, no additional deaths were found. (The absence of birth certificates for the excluded and unlinked names increases the possibility of their being undercounted.) Potential undercounting notwithstanding, from the moment of viability, defined by the existence of a birth certificate, the WIC and control samples looked different in terms of subsequent neonatal mortality. Nevertheless, some caution must be used in interpreting the magnitude of the mortality findings. Further research confirmation is needed before extrapolations to other high-risk populations are warranted.

Comparative information on all fetal deaths was not available to this study; the non-WIC control sample was selected from a population of viable births (e.g., infants having a birth certificate). Thus the WIC and control populations could not be compared over the full range of fetal outcomes.

The improvement in prenatal care among WIC participants, especially the decrease in the per cent of women with inadequate prenatal care, has not been demonstrated previously. Whether WIC participation encourages more subsequent utilization of health care, as some researchers have noted,[12] or whether better prenatal care leads to increased WIC enrollments cannot be determined from this study. All

prenatal WIC participants must document their pregnancy status, an act that encourages a formal prenatal care visit and thereby increases the likelihood of being drawn at an early stage into a prenatal care health network. Improved prenatal care is both an important goal and an achievement of the WIC program.

Benefits associated with WIC participation do not appear limited to any particular population group, but are seen across a wide spectrum of subpopulations. Subpopulations at higher nutritional risk for poor pregnancy outcomes, however, appear to benefit more strongly, especially teenage, unmarried, and Hispanic origin women. In general, the neediest populations seem to benefit the most from the WIC program.

Increased duration of participation in the WIC program appears to be associated with enhanced birth outcomes, in general accord with prior WIC research.[3,4] The birth outcomes for the longest duration WIC participants reach or surpass the State's overall mean birthweight (3343 grams) and incidence of LBW (6.55 per cent).

Estimating the exact magnitude of the cumulative benefits associated with increased duration of participation in WIC is methodologically complicated. Duration of participation and gestational age are, in part, confounded. WIC benefits may be mediated through increased gestational age but in turn, increased gestational age allows for increased duration in WIC. Any grouping of subjects for statistical analysis on the basis of extensive absolute duration of participation in WIC virtually assures that they have longer gestations and higher birthweight; while any statistical corrections for length of gestation will eliminate the benefits associated with the program's enhancement of gestational age.

Since no ideal analytic solution exists,[13] we used two alternative methods: absolute duration in WIC, and percentage of pregnancy in WIC. Since the absolute duration measure may be an over-estimation and the percentage of pregnancy may be an under-estimation, we suggest that the magnitude of the cumulative benefits associated with WIC should fall between these two estimates. Both methods of analyses imply that more extensive WIC participation is associated with more beneficial birth outcomes. The absolute duration analysis would indicate that the benefits are not simply linear; WIC participation greater than six months would appear maximally beneficial.

It is not only chance or self-motivation that determines if a person enters WIC early or late. Barriers and incentives to early participation exist. Haddad and Willis[14] have shown that the probability of women entering WIC in their first three months of pregnancy is significantly enhanced if the WIC program site has been open a long time, delivers it supplementation through retail stores, and uses public service announcements. The potential benefits associated with the WIC program are not yet being reached; only 22 per cent of the WIC prenatal participants participated for more than six months.

The comprehensiveness of the case population is an important element in assessing the validity and generalizability of the present study. The names of 525 women administratively excluded from the WIC prenatal program were omitted from this study. Unfortunately, very little demographic or motivational information is available about them from the WIC computerized records. The 353 names, which had no reason specified for their exclusion, were similar racially to the WIC study population (68.6 per cent White excluded group vs 73.6 per cent study group). We are doubtful that most of these 353 names led to an actual Massachusetts birth. Less than 10 per cent of these women had locatable birth certificates. Abortions, fraud, computer errors, and out-of-state moves are the more likely unrecorded realities for these names.† Women do not always inform the WIC program of their reasons for discontinuance. Nevertheless, one cannot rule out of the possibility that the administratively excluded names may have had specific characteristics which would bias the overall study results.

The birth certificates for 191 women who were in the WIC program prenatally could not be located. Again, little epidemiologic information is available about these women. Racially (based on their WIC records) they are similar; their duration of participation in WIC is essentially the same as the WIC group. No fetal deaths were located among this group. One can not rule out the possibility that they may have had specific characteristics which would bias the overall results. Five WIC women with birth certificates were not matched to controls.

Overall, we estimate that at least 95 per cent of the WIC prenatal participant population were included in the study which represents the largest and most comprehensive series on WIC prenatal participants to date.

Establishing the existence and magnitude of a WIC program effect also depends critically on the comparability of the WIC and matched control groups. Unfortunately, there are inherent limitations to the conclusions that can be drawn from a retrospective cohort study in which the exposure (WIC) group is self-selected and the control group is derived by a post-hoc matching procedure. A more ideal randomized case control study would pose serious ethical dilemmas. Since many known confounding factors have been controlled, we believe that the statistical differences between the WIC and control groups are a function of WIC participation; however, additional confounding factors may also be characteristic of the WIC or control populations and account for any birth outcome differences noted.

The Massachusetts birth certificates do not provide specific information on maternal pre-pregnancy weight or height, maternal weight gain, maternal smoking habits, or maternal morbidity. Any of these factors, if unevenly distributed, may be sufficient to distort the overall outcomes. WIC participants may be more strongly motivated to improve the prenatal health of their future offspring than are the control women. Such a motivational difference could cause both an improvement in pregnancy outcome and a desire to enroll in the WIC program. The findings of earlier and more frequent prenatal care visits may be supportive of this view. The increase in prenatal care may also be the cause of the improved birth outcomes, and not simply another consequence of WIC participation. The lack of prenatal care improvements among Hispanic origin women who show enhanced birth outcomes argues somewhat against this interpretation. The present study design does not lend itself to a study of prenatal care, nutrition supplementation, or nutrition counseling independently of each other.

Although these alternative explanations for the birth outcome differences tend to suggest that the attributed WIC program effects may be over-estimated, an under-estimation may be just as likely. The WIC population could be financial-

† Women who delivered prematurely, even shortly after joining the WIC program, would not be administratively excluded; these women would be switched to the WIC postpartum program and their birth records included in this study.

ly poorer and at greater obstetric risk than their matched controls. All WIC participants must have an income under 195 per cent of the poverty level, while the controls have no restrictions on income, and presumably some have higher incomes. Post-hoc analyses reveal that there were more women of Hispanic origin in the WIC than the control sample (906 vs 509). And WIC participants are selected, in part, on the basis of poor prior obstetrical histories, while no such criteria exists for the control group. These potential confounding factors in a matched study design would decrease the likelihood of showing positive birth outcomes associated with WIC participation.

In summary, the Massachusetts WIC Statewide Evaluation Project compared the birth outcomes of 4,126 WIC prenatal participants and 4,126 individually matched controls, utilizing public birth and death certificates. Results showed that the WIC program appears to be targeted to women at high demographic risk for poor pregnancy outcomes; that overall WIC participation is associated with small improvements in mean birth characteristics, larger reductions in marginal pregnancy outcomes, and enhanced prenatal care; and, that these benefits are observed more strongly in higher risk subpopulations and are enhanced with increased duration of participation. Based on the information available to this study, we conclude that participation in the WIC prenatal program is associated with improved pregnancy outcomes for women at high nutritional and financial risk.

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APPENDIX A

Derivation of Study Population: Massachusetts WIC Evaluation Project

Number of Names of Eligible WIC Prenatal Participants		4,898
Number of Excluded Names	525	
Known moved out-of-state	18	
Known abortions and miscarriages	62	
Computer errors	82	
Terminated for cause from program*	353	
Number of Names Eligible for Study		4,373
Number of Omitted and Unlinked Names	252	
Twins omitted	46	
Stillbirths omitted (no birth certificates)	15	
Unlinked (no birth certificate found)**	191	
Number of Unmatched Names	5	
No control found	5	
Number of WIC Prenatal Participants Linked to their Infant's Birth Certificate and Matched to a Control		4,126
Per Cent Study Cases of Eligible WIC Names		95%

*Causes for administrative termination include: non-use of issued vouchers, no longer at nutritional risk, violations of regulations, no longer income eligible, possible fraud.
**Reasons include: out-of-state move, name changes, possible fraud.

APPENDIX B

Matching Criteria between WIC and Control Samples

Age (years): 15 & under, 16–17, 18–19, 20–24, 25–29, 30–34, 35+
Race*: Black, White, Oriental, Other
Parity: 1, 2, 3, 4, 5+
Years of Education: 8 and under, 9–11, 12, 13–16, 17 or more
Marital Status: Married, Unmarried

*Hispanic ethnicity is coded racially as White on birth certificates following the NCHS convention.